

# Internet Rack Monitor

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## Introduction

This note describes the design of a general purpose data acquisition chassis based on the Motorola MVME-162. The Internet Rack Monitor (IRM) is an intelligent data acquisition system containing the processor, network connection and the analog and digital I/O in the same chassis. As its name suggests, this device is a node on the world-wide Internet. A local database within each IRM allows it to function as a stand-alone control system for equipment it controls.

## General description

For several years, the *Standard Model* for accelerator control systems has been workstation consoles connected to VMEbus local stations by a Local Area Network. Analog and digital data has often been accessed using a field bus to custom I/O interface electronics. Commercially available hardware has now made it possible to implement a small stand-alone data acquisition station that combines the LAN connection, the computer, and the analog and digital I/O interface on a single board. This eliminates the need for a field bus and the associated proprietary I/O hardware. A minimum control system is one station and a Macintosh or workstation console both connected to the network; larger systems have more consoles and nodes.

A Motorola MVME162 single board computer includes the usual serial ports and memory along with an Ethernet adapter and four IndustryPack™ daughterboard sockets for I/O interface. The MVME162 can be configured as a VMEbus cpu or as an embedded controller. Both configurations execute the Fermilab Local Station software that performs data acquisition, control loops, alarm scanning, and TCP/IP communication on Internet. In large installations, any local station can serve as a concentrator node to collect data from several other stations on behalf of a remote console.

## Overview of the Internet Rack Monitor

Figure 1 shows the block diagram of the Internet Rack Monitor (IRM). The overall arrangement of I/O is patterned after the DZero Rack Monitor and the Smart Rack Monitor (SRM) used in the Linac Upgrade. Similarities are the 64-channel differential A-D input, eight bytes of digital I/O and eight of D-A output channels. The rear panel connector arrangement shown in Figure 2 is similar to earlier models. In contrast with previous versions, this device is based on a commercially available VMEbus single board computer. Characteristics of the Internet Rack Monitor are:

- Runs *Local Station* Software
- Operates as an Internet node
- Ethernet LAN Interface
- 64 Channel Multiplexed A-D
- 8 Bytes of digital I/O
- 8 Channel 12-bit D-A
- I/O expansion via IndustryPack Modules

Earlier version rack monitors functioned as I/O chassis connected to a VMEbus crate. The IRM differs architecturally in that no VMEbus crate is required unless special VMEbus-based I/O cards are needed in a particular application. In that case, the MVME-162 card is installed in the VMEbus crate rather than the IRM 2U chassis. The software is identical for the two cases.

## The MVME-162 Single Board Computer

The recently released MVME-162 computer includes the following:

- Motorola 25 Mhz MC68040 Processor
- Ethernet Network Interface
- Optional SCSI interface
- 4 MBytes of dynamic RAM
- 512 KBytes Static RAM with Battery Backup
- 1 MByte of Flash Non-volatile memory
- 8 KByte NVRAM with time-of-day clock
- PROM Socket
- 4 32-bit programmable timers
- 2 Watchdog timers
- 4 IndustryPack I/O sockets

IndustryPack sockets can contain custom designed modules, such as TCik processors, or any of several dozen commercially available modules.

## Analog Input

Four connectors on the rear panel of the SRM are used to connect the analog inputs to eight 8-channel

differential input multiplexers. Outputs from these multiplexers are combined by a ninth multiplexer that drives an instrumentation amplifier followed by the digitizer. The A-D converter is an Analog Devices 676 16-bit, 10  $\mu$ s digitizer that uses a successive approximation charge redistribution digitizing technique and includes an onboard microcontroller to recalibrate the device at power-on time or by external command. An input signal sample-and-hold function is inherent in the design of these converters.

A custom IndustryPack (IP) module connects the MVME-162 to the analog I/O board. As shown in Figure 3, the main component of this analog control card is the Actel 1240 field programmable gate array that provides the following features:

- Operates offboard A-D and D-A
- Repetitive 64 channel scan mode
- 1000 Hz or External scan rate
- Stores A-D results sequentially in RAM
- Arbitrates IP and A-D access to 64kB RAM

An Analog Devices AD75089 octal D-A chip is included on the analog board. D-A registers appear as memory locations that can be read and set. The output range of these converters is  $\pm 10$ V. A read of the setting register returns the stored setting of selected D-A registers.

### Digital I/O

The IRM normally uses the 74ABT652 as its digital I/O chip, a non-inverting bi-directional octal latch-buffer circuit with high active totem pole outputs. All digital I/O lines are pulled to +5V with 1 kohm pullup resistors. A "1" written to a digital output bit will drive the corresponding pin high and read back as a "1". The data direction of the digital I/O is separately determined for each byte by a rear panel piano DIP switch. A *Read* of an I/O byte returns the state of the pin, not the logic value stored in the latch. Digital I/O is accessible as bytes of memory so the software can interact with individual I/O bits using the processor's indivisible BSET and BCLR instructions. Two bytes of digital data are connected to each of the four 37-socket "D" connectors. Also included in each connector are two strobe signals to indicate a processor access to each of the two bytes, a buffered R/W line that gives the direction of the data transfer, and a +5V line that can be used to activate external opto isolators or small relays. Because each I/O bit is internally pulled up, external isolated contact closures can be sensed directly, without connection to the user's power or ground.

For special applications, other digital I/O chips may be used. The 74ABT651,2,3 and 4 are a pin-compatible family of interface buffers that provide all combinations of inverting and non-inverting, totem pole and open collector outputs. Totem pole versions can sink 64 milliamps to a TTL low, and drive 32 milliamps to a TTL high.

The digital I/O board is controlled by an IndustryPack on the MVME-162 computer board. This IP module is the same as the analog IP controller with a different Actel chip providing the following capabilities:

- Controls 8 bytes of offboard I-O
- TCLK interface
- Predet for  $\mu$ P start time
- Latches for clock event recording
- Supports 1 byte of sense switch input
- Provides 1 byte of LED indicators

The pinout of both the analog and the digital interface boards is shown in Figure 4.

### Network Interface

An Ethernet adapter is included on the MVME-162 cpu card. Ethernet signals from row C of P2 are cabled to a standard 15-pin "D" connector compatible with the Ethernet transceiver specification. For installations where "Thin Ethernet" is needed, a small commercially available transceiver-to-thin-net module may be installed internal to the chassis. The Ethernet interface is then a single BNC connector. Cabling between the MVME-162 P2 Connector and the Ethernet transceiver connector is given in figure 5.

### I/O Daughterboard

Because only two of the four available IndustryPack sockets are required to interface the analog and digital I/O boards, other IPs can be added to the system. A variety of commercially available IndustryPacks can be used as well as custom designed modules. Space is provided on the back panel for additional interface connectors. In accelerator installations, accelerator clock processors that generate delay triggers from events decoded from the accelerator clock can be installed in spare IP sockets.

### Packaging

The IRM is packaged in a self-powered 2U (3.5 in.) rack mount chassis and all I/O is attached using socket type "D" connectors mounted to the rear panel. Pinout of the analog and digital I/O connectors is the same as previous versions of rack monitors.

**Software**

After several years of development, the Fermilab Local Station software provides much of the capability needed by several types of accelerators. Each Local Station is a stand-alone control system containing a local database for the equipment it controls. Remote hosts can request repetitive readings of and make settings to hardware devices over the network. Each analog channel and each bit of digital I/O can be monitored for alarm conditions. Alarm messages are sent to host computers over the network. Because the local station contains descriptors and calibrations for the data channels, data can be requested by channel name, and alarm messages describe out of tolerance conditions using the names of the data

channels. New features can be added by installing separately compiled *local application* programs in selected stations. Software, local database, hardware settings and configuration tables describing what data to acquire are all kept in non-volatile memory so that each rack monitor can power up fully operational without needing to be downloaded from a host.

**Current Status**

A prototype version of the Internet Rack Monitor has been assembled and is being tested. The current version of Local Station software has been converted to operate using Ethernet on the MVME-162 computer board. Circuit boards for the IP interface module, the analog I/O board, and the digital I/O board have been fabricated and tested.



## Features of the Motorola MVME-162

- Motorola 25 MHz MC68040 Processor
- Ethernet Network Interface
- Optional SCSI interface
- 4 MBytes of dynamic RAM
- 512 KBytes of Static RAM with battery Backup
- 1 MByte Flash non-volatile memory
- 8 KByte NVRAM with time-of-day-clock
- PROM socket
- 4 32-bit programmable timers
- 2 Watchdog timers
- 4 *IndustryPack* I/O sockets

## Characteristics of the 162-Rack Monitor

- Runs *Local Station* Software
- Operates as an *Internet* Node
- Ethernet LAN Interface
- 64 Channel A-D
- 8 Bytes of digital I/O
- 8 Channel 12-bit D-A
- IndustryPack Digital I/O driver
  - Drives offboard digital I/O
  - TClk interface
  - Predet for  $\mu$ P Start time
  - Latches for clock event recording
  - Provides 1 byte sense switches, 3 bytes LED indicators
- IndustryPack Analog I/O driver (same as digital module)
  - Operates offboard A-D and D-A
  - 1000 Hz continuous 64-chan scan mode
  - Stores A-D results in RAM
  - Arbitrates IP and A-D access to RAM
- 2 Additional IndustryPack sockets
  - Accepts commercial I/O cards
  - TClk generator card
  - 4-channel TClk predet card
  - Arcnet card

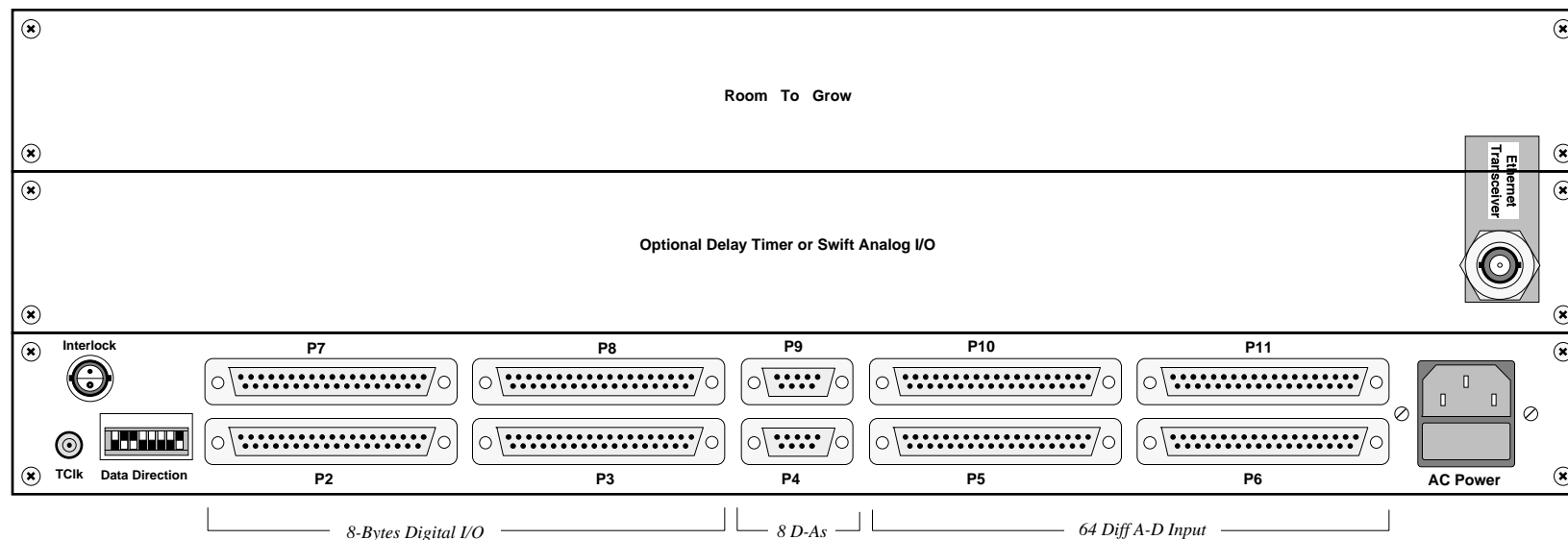
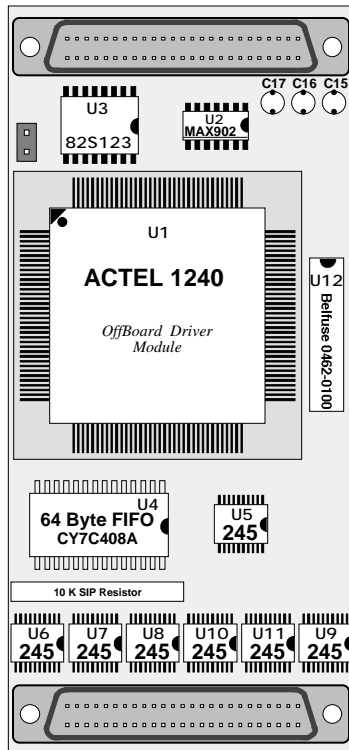
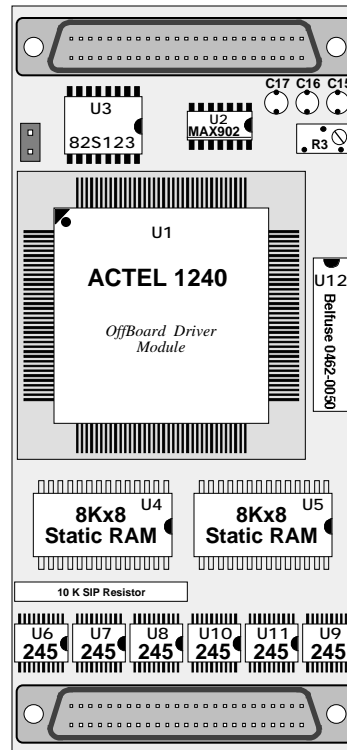


Figure 2. Back Panel for MVME162-Based Rack Monitor

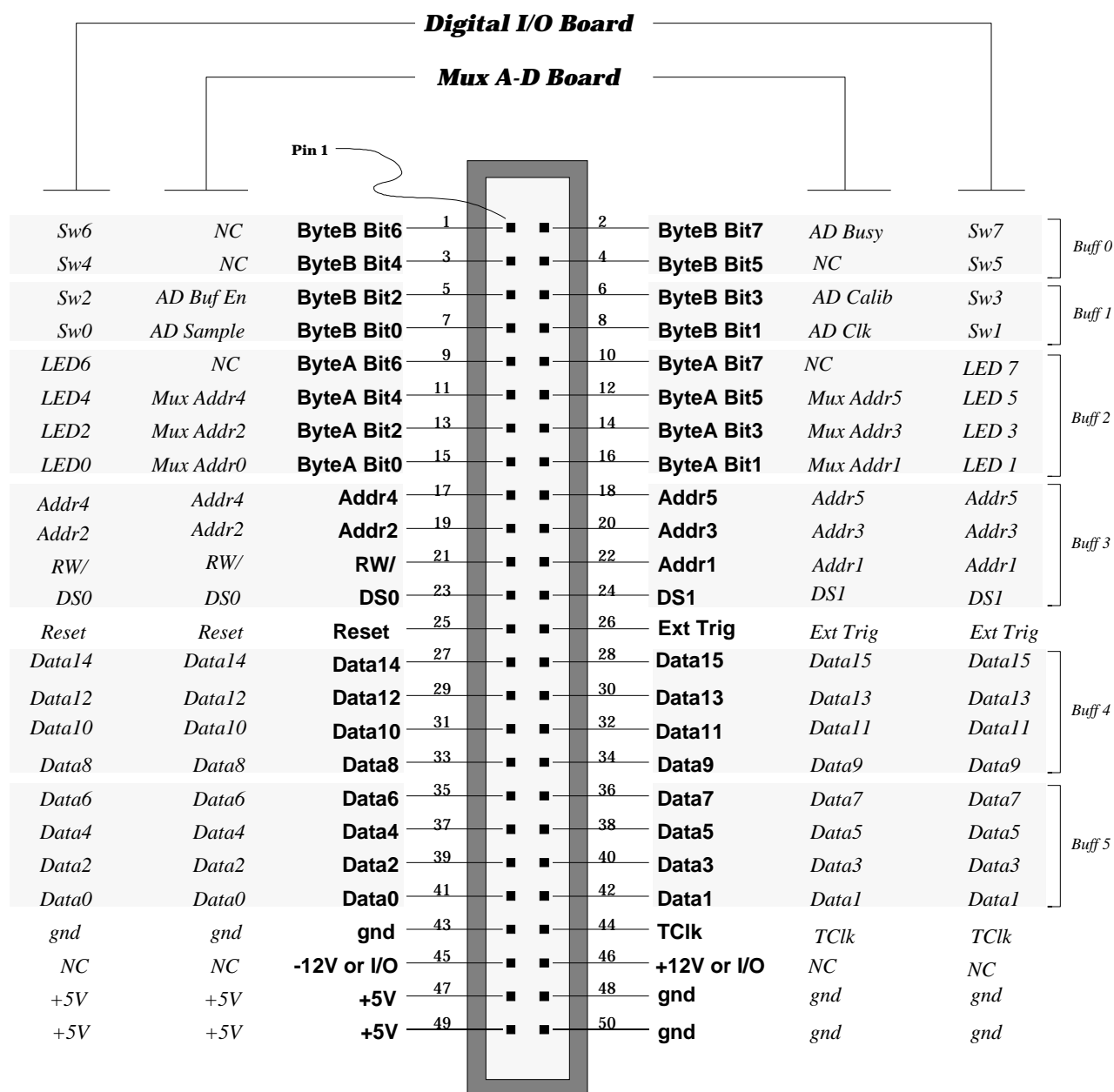


**Digital Interface**

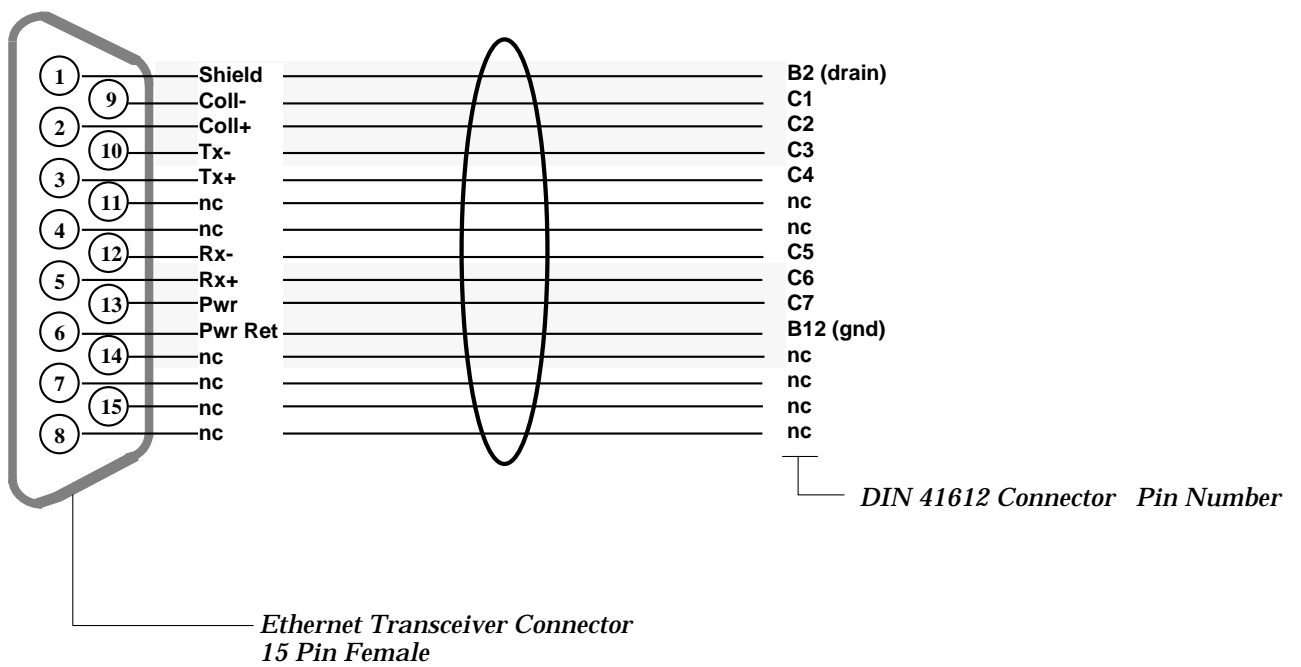


**Analog Interface**

**Figure 3. Off Board Interface IP Module**



**Figure 4. I/O Interface Driver Connector Pinout**



**Figure 5. Ethernet Cabling Diagram for the MVME-162**